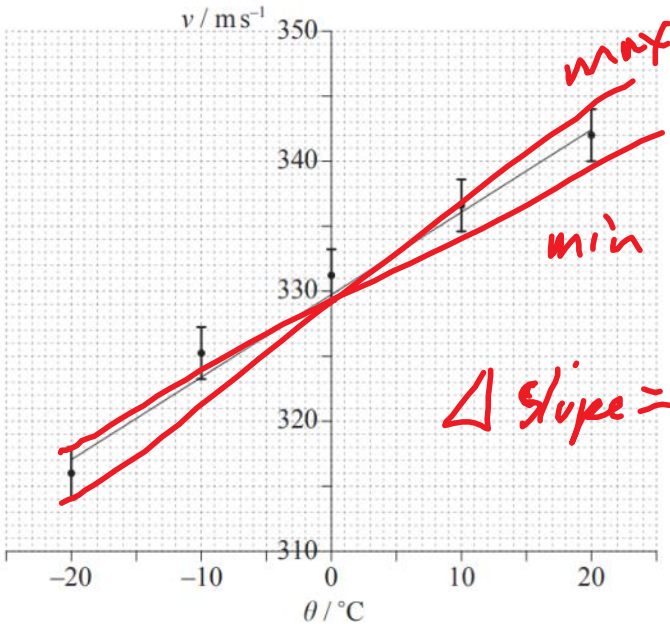
SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. The speed of sound in air, v, was measured at temperatures near 0°C. The graph shows the data and the line of best-fit. The error bars for temperature are too small to be shown.



max slopp

min slopp

Δ slope $= \frac{\text{max - min}}{2}$

A student suggests that the speed of sound v is related to the temperature θ in degrees Celsius by the equation

$$v = a + b\theta$$

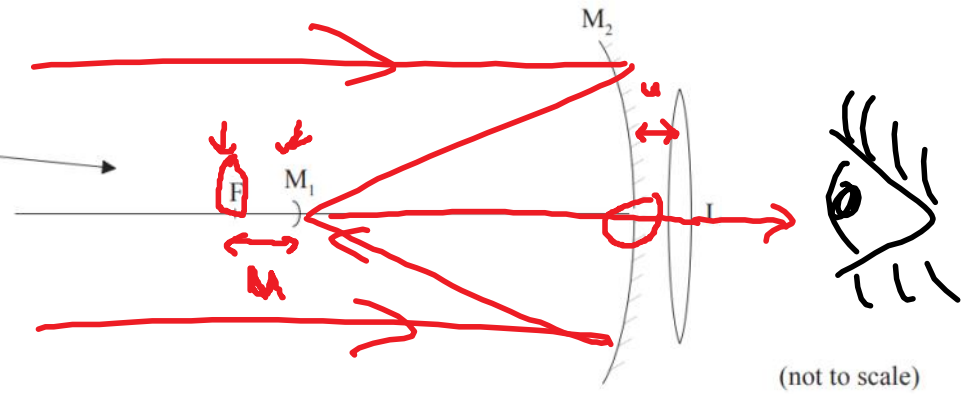
$$-Q_{metal} = Q_{water}$$

$$-Q_{mat} + Q_{extra} = Q_{water}$$

$$-m_m C_m (T_E - T_i) + Q = m_w C_w (T_E - T_w)$$

option

8. (a) The diagram shows a Cassegrain reflecting telescope consisting of a small diverging mirror M_1, a large converging mirror M_2, and a converging lens L. The focal point of M_2 is at F.



The telescope is used to view a planet. The diameter of the planet subtends an angle of 1.40×10^{-4} rad at M_2. The focal length of M_2 is 9.50 m.

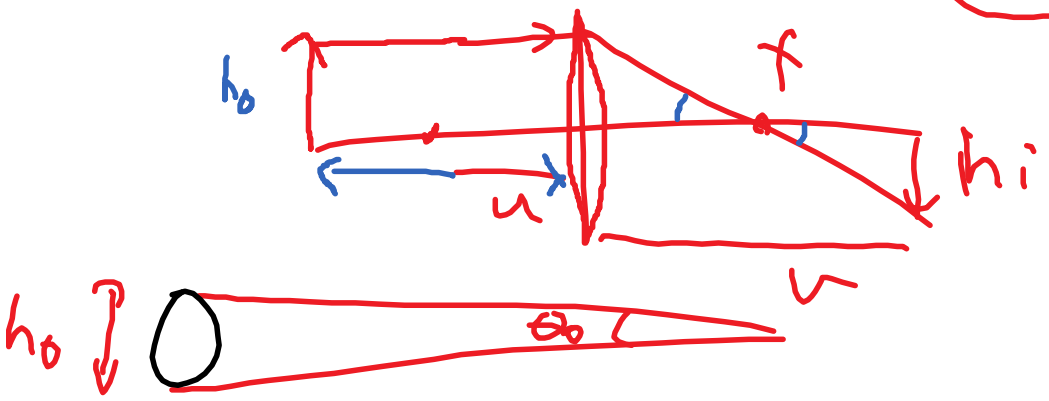
(i) Show that the diameter of the image of the planet that would be formed by M_2 alone is 1.33 mm. *[3]*

$\theta_0 = 1.4 \times 10^{-4}$ rad $f = 9.50$ m

if u is very big $f \approx v$

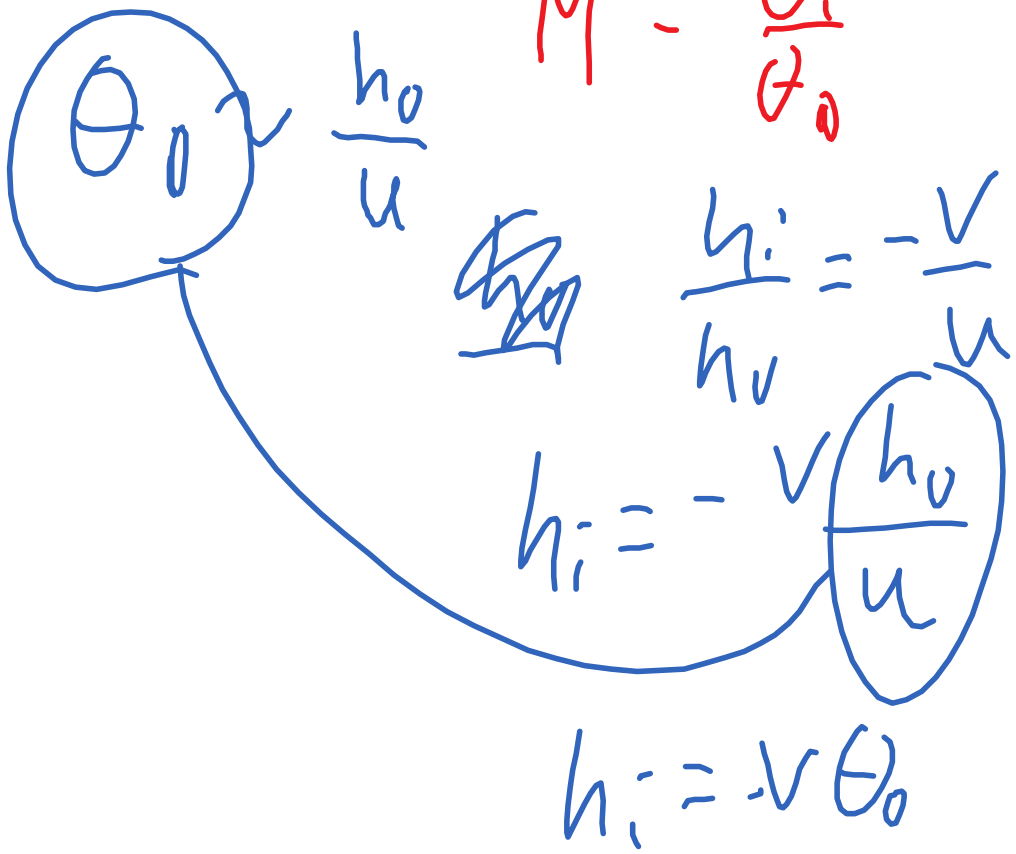
$D_i = -f\theta_0 \approx -9.50\text{m} \times 1.4 \times 10^{-4}$

$= -1.33$ mm



$$\frac{1}{F} = \frac{1}{v} + \frac{1}{u} \qquad m = \frac{h_i}{h_0} = -\frac{v}{u}$$

$$M = \frac{\theta_i}{\theta_0}$$



$$h_i = -v\theta_0$$

(Option C, question 8 continued)

(ii) M_1 is at a distance of 8.57 m from the aperture of M_2. The image in (a)(i) now serves as a virtual object for M_1. A real image is formed at the opening of M_2. Show that the diameter of this image is 12.0 mm. *[3]*

$v = 8.57\,m$ $\quad D_0 = 12.0\,mm$

$\frac{D_1}{D_0} = \frac{-v}{u}$ $\quad D_1 = -D_0\frac{v}{u}$ $\quad = \frac{+1.33\,mm \times 8.57\,m}{(9.50\,m - 8.57\,m)}$

$= 12\,mm$

(iii) The real image in (a)(ii) is now viewed by L of focal length 98.0 mm. The final image of the planet is formed at infinity. Calculate the overall magnification of the telescope. *[3]*

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$M = ?$ $\quad v = \infty$ $\quad u = f$

$M = \frac{\alpha_i}{\alpha_o} =$

1.4×10^{-4} rad

$12\,mm/98\,m = 1.2 \times 10^{-4}$ rad

(Option C continues on the following page)